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Promoting STEM Literacy in 21st Century Education

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INTRODUCTION:

"Even with unemployment at historically high levels, large numbers of jobs are going unfilled. Many of these jobs have on thing in common – the need for an educational background in science, technology, engineering, and mathematics." This was a quote from former governor of Michigan, John Engler (2012); published in the article *STEM Education Is the Key to the U.S.'s Economic Future*. STEM literacy refers to the knowledge, background and ability to think critically in the areas of science, technology, engineering, and mathematics. Today, there is a high demand for STEM-related talent and this trend is only going to continue in the future. In order to compete globally as a nation, we need to develop STEM talent. Engler states that while the overall unemployment rate is striking low, there are many jobs that are going unfilled. He states that the reason these jobs are going unfilled is due to the lack of people with the right skills. William Swanson, Raytheon Chairman and CEO, was quoted in Engler's article (2012) saying "Too many students and adults are training for jobs in which labor surpluses exist and demand is low, while high-demand jobs, particularly those in STEM fields go unfilled." According to Engler's article (2012) a recent survey was done to determine why so many young people stray far from fields in science, technology, engineering, and mathematics. Many stated that they lack knowledge about fields in these areas, some stated that fields in these areas were too challenging, while others stated that they were not well prepared in school to pursue higher education and careers in these areas. From these responses, one can see that the key to conquering this global problem is to make changes to our educational system. In order to promote students to enter STEM-related fields, one must teach them to think critically in the fields or science, technology, engineering and mathematics and to provide them with real-life knowledge and experiences that spark their interest in these fields. STEM literacy is the way to

do this. This research paper is composed of two different parts, with the first part focusing on how to incorporate literacy into science and mathematical instruction, and the second part on incorporating engineering and technology into both of these subject areas to enhance literacy and understanding.

PART I:

This section of the research paper will focus how to effectively incorporate scientific and mathematical literacy into the science and math classroom. Each section contains five research articles that present methods and strategies on enhancing literacy in the designated content area.

Science

According to the article titled *Connecting Students to Science Through Structured Reading of Historical Nonfiction*, William J. Straits, Susan Gomez Zweip, and Russell Wilke (2011) believe that the use of historical non-fiction can aid in the teaching of scientific content. The authors state that there are many second tier students, those students who seek to avoid the sciences or end up leaving the sciences, who struggle with its relevance. They often question how the various methods they are learning have come to be, why scientists understand nature the way they do, and what the connections are between what they are learning and the larger world (Straits et al., 2011, p. 26). The authors of this article discuss a method that incorporates the reading of historical nonfiction with literature circles to help answer these questions that many students' struggle with in their study of science. When studying science it is important to link the history of science, also known as HOS, with the nature of science, otherwise known as NOS. One of these without the other does not complete a satisfying scientific picture for students. The National Science Education Standards, NSES, supports the use of HOS and NOS, believing that both help students' master the learning of scientific material. However, above all else, instructors

must seek to help students' personalize science. Through the use of HOS and NOS, students' must be presented with the opportunity to identify with science in personal and meaningful ways. The use of historical non-fiction is an excellent tool to help accomplish this. In today's society there is a huge historical non-fiction genre available for instructors to utilize. However, the reading of text needs to be accompanied with literature circles to promote the proper aspects of specific scientific content information and the key issues of HOS and NOS. Literature circles involve small discussions in which students are broken down into groups of three to five. Prompts will be provided that pertain to the reading and each group will be given twenty to thirty minutes, varying from one to five class sessions, for discussion. These prompts will focus on directing and guiding their attention in the reading and maximizing student participation (Straits et al., 2011, p. 28). The ultimate and primary goal of the prompts is to help students' make personal connections with the content material. Students take notes while reading that will be used for their discussion. The provided prompts help to guide and structure their notes. The chosen historical non-fiction text should relate directly to the topic being discussed in class. The small group discussions should expand beyond the mere reporting of facts. The conversations should be open-ended and personal opinions should be freely shared. The idea of literature circles takes on the viewpoint of the social constructivists. Through social constructivism, students' will share their opinions and listen to the opinions and ideas of others. Through this exercise, students' will be exposed to multiple possibilities. The authors of this article applied these literature circles to two different college level courses and explored the outcomes. The first course was a science capstone course at an urban university in southern California. The class was composed of a diverse population, but all were non-science majors. The class read a chapter from the book "The Panda's Thumb," which related the topic of landforms and erosion that they

were studying in class. The prompt had students focus on the impact of existing scientific and social beliefs on the practice of scientists and how the values of competing ideas in science are weighed (Straits, et al., 2011, p. 30). After reading students' reflections relating to the discussion and prompts, the authors were very satisfied with the results. The reflections shared content material that students' had learned, their opinions about it, and how they personally connected to the subject topic. The second college course that the authors applied literature circles to was a human anatomy class at a small university in rural southwestern Texas. The majority of students' in this class were nursing majors. This class read excerpts from the books "Human Remains: Dissection and Its Histories," "Stiff: The Curious Lives of Human Cadavers," and "The Panda's Thumb." The prompt provided to them focused on the tentative nature of science, the role of objectivity in science, and the relationship between science and society (Straits et al., 2011, p. 30). The results of this study proved very satisfying as well. Like the previous study, personal reflections showed vivid connections between HOS, NOS, content material, and personal meaning. The use of literature circles was based on Rosenblatt's (1978) Reader Response Theory. In this theory the idea of efferent and aesthetic stances were taken. Efferent refers to the meaning that readers take from text (Straits et al., 2011, p. 30). However, aesthetic refers to the personal life experiences that readers bring to the text (Straits et al., 2011, p. 30). Quality scientific instruction should refer to both of these stances and the use of historical non-fiction accompanied by literature circles accomplishes this task. This literature-based approach used in scientific instruction is an effective way to reach out to those students' who are hovering away from the exploration of science. Sally G. Hoskins also presents how to incorporate reading into the science classroom.

According to the article "*But if It's in the Newspaper, Doesn't That Mean It's True?" Developing Critical Reading & Analysis Skills by Evaluating Newspaper Sciences with CREATE*, Sally G. Hoskins (2010) believes that newspapers are the key to a successful science curriculum. Through the use of a method called CREATE, Hoskins incorporated reading into the science classroom through use of newspapers. CREATE is an acronym for Consider, Read, Elucidate hypotheses, Analyze and interpret data, and Think of the next Experiment. Through CREATE students became familiar with primary scientific literature, learning to read and understand it, while simultaneously increasing their interest. Hoskins develops CREATE-based lesson plans involving activities that focus on the analysis of a brief newspaper article. These lessons provide students' with a structured approach that can be used for any scientific reading, jolt students' out of passivity with exercises that require them to use both their critical thinking faculties and their creativity, and highlight both how science works and issues of science and society (Hoskins, 2010, p. 2). Each lesson is geared to take approximately an hour and a half and is built on five sequential steps. The first step is called "Consider." In this step a group concept-mapping activity is used. A large class concept map is made on the designated topic. The teacher organizes the concept map on the blackboard as students' call out their ideas. This step is used to review background material and basic concepts, and to help students' understand the article. Next, the students' skim the article, looking for general themes that should be added to the concept map. The next step in CREATE is called "Read." In this step students' read the article completely, looking up any words they do not know. Students' then work in groups to draw outlines of how the study was conducted. Then, students' were then told to construct what the data must have looked like. The teacher helped students think about this by asking guided questions that probed the students mind about the data presented in the article and the best way

of representing it. For example, the data could have been represented using a chart or a graph. The students must work together and come up with a representation of the data presented. This challenges students, causing them to work backwards from the information given in the newspaper article and think critically about the experiment. The next step in CREATE is called "Elucidate the Hypotheses." In this step students form groups and explore what the central question or hypothesis of the experiment was. This step is often challenging for students because in a newspaper article, the experiment is not organized into introduction, methods, results, and discussion sections like a research journal would be. The information is all summarized and students' must focus on the "big picture" of the article, rather then the small details. The next step in CREATE is called "Analyze & Interpret the Data." In this step the instructor asks students guided questions. They must use the article to come up with answers to the questions. These questions presented to students are challenging and consider particular issues within the experiment. This step helps students see the challenges faced by scientist in designing and interpreting comparable studies, realize they may often confuse correlation with proof, and learn that taking newspaper science at face value may be unwise (Hoskins, 2010, p. 4). The next step in CREATE is called "Think of the Next Experiment." In this step students must chose one hypothesis that was discussed in class and create an experiment to test it. Students will do this in small groups. Then each group will share their experimental design with the entire class. From this, the class will decide which experiment is the best to implement. Hoskins believes that CREATE is an excellent way to bring important scientific issues into the classroom and that this is accomplished through the use of literature, particularly newspapers. Through the use of CREATE and the reading of newspapers, Hoskins believes that students learn to think like

scientist. Natalie Heisey and Linda Kucan are two authors who also provide suggestions for incorporating reading into the science classroom.

According to the article *Introducing Science Concepts to Primary Students Through Read-Alouds: Interactions and Multiple Texts Make the Difference*, Natalie Heisey and Linda Kucan (2010) believe that incorporating reading into the science classroom can be done through teacher-led-read-alouds. It is through these read alouds that students can engage and understand text above their reading level (Heisey et al., 2010, p. 667). During read alouds, discussion should be generated that focuses on interpretations, offering suggestions, and asking questions (Heisey et al., 2010, p. 666). This will help ensure that students' are achieving maximum comprehension. Discussions that occur during the read aloud process are refereed to as Text Talk. Teacher-led-read-alouds also act as a way to introduce challenging content information to students, especially vocabulary. In this article an experiment was conducted that compared rather the discussions of read alouds should take place during the reading and cover small chunks of text, or after the entire reading has been finished. Thus, there were two groups, the during-reading group and the after-reading group. Each groups focused on the reading of three texts. The three texts were the same for each group. The specific questions asked by the researchers focused on differences in comprehension between the two groups, and how the discussion varied between the two groups. Scripts were generated to lead the during-reading discussion. Questions focused on drawing attention to a scientist at work, content-specific information, assisting students' in making connections to previously read text, and supporting students understanding of important science-related vocabulary. These same questions were addressed in the after-reading group; however, they were not discussed until after the entire text had been read. Heisey and Kucan used a variety of tests to gather their results and determine their conclusions. These tests included after-story

tests, pre-tests and post-tests. Results showed that students in the during-reading groups were able to provide better answers and more support for their answers on these tests. The tests also supported the fact that students who were in the during-reading group showed greater gain and progress than those in the after-reading group (Heisey et al., 2010, p. 671). The authors concluded that the incorporation of text into science instruction provide a unique way for students to learn about and understand the work of scientists. Rich Radcliffe, David Caverly, James Hand and Deanna Franke are also authors who present suggestions for incorporating literacy into the science classroom.

According to the article *Improving Reading in a Middle School Science Classroom*, Rich Radcliffe, David Caverly, James Hand, and Deanna Franke (2008) believe that reading in the middle school science classrooms is important. The authors believe that incorporation of literacy into middle school science classrooms should be done using a strategy called PLAN. PLAN stands for predict, locate, add, and note and is a strategy used to help students comprehend and study textbooks effectively. They performed a study with the purpose being to examine the effects of introducing the PLAN reading strategy into a middle school science classroom. Specifically they examined how a middle school teacher changed her instruction over a school semester as she implemented PLAN, if PLAN was effective in helping middle school students learn science, how students perceived their use of the strategy, and if a teacher's confidence and competence in their ability to teach a reading strategy in science class changed as PLAN was implemented. The authors state that reading is highly emphasized in elementary school, but seems to become less emphasized as students reach their middle and high school years. One of the most main problems with reading in the science classroom during middle and high school years is the textbook. The authors state that eighty percent of science teachers admit to using the

required textbook regularly, but that many factors exist that make the use of the textbook ineffective. Textbooks are often very challenging, requiring a large vocabulary, and presenting a confusing text structure. For this reason, students don't learn what they should from their textbooks. However, with the use of PLAN this can change. The particular study conduced by these authors involved a middle school teacher and two of her classes. One class acted as the control group and continued the semester out with her traditional approach to reading the textbook. This traditional approach was to play a tape of someone reading the text, as the students followed along silently in their textbooks. Another class acted as the treatment class and under went the implementation of PLAN. The actual procedure involved with the PLAN strategy takes students through a series of steps when reading their textbooks. Students begin by predicting the content of the text. They use these predictions to create a concept map. Next, students locate what is known and not known by placing checkmarks or question marks on certain areas of the concept map. Next, while reading the text, students add links to the concept map. This helps students confirm what they know and discover what they do not know. Finally, upon completion of reading, students note a revised or reformulated understanding. They do this by making corrections to their concept map and writing summaries. The teacher introduced this strategy in a way that resembled Pearson and Gallagher's steps of explicit instruction. That is, the teacher modeled the strategy for the entire class, then provided scaffolding through group practice, and eventually, made time for individual practice. The findings presented by the author show many positive results. Overall, students stated that they enjoyed using the PLAN strategy because if was fun, enjoyable, and the material made sense. The treatment group became much more enthusiastic about reading. A post-test was given in order to show statistical data. This post-test covered the same topic because both the control group and the treatment group were

learning the same concepts, but in different ways. The results of this post-test showed that the treatment group had significantly higher scores than the control group. The use of PLAN is an effective strategy that should be used to implement literacy into the sciences because it creates increased self-esteem in students and independent scientifically literate students. Jane Devick-Fry and Teresa LeSage are also two authors who present suggestions for incorporating literacy into the science classroom.

According to the article *Science Literacy Circles: Big Ideas About Science*, Jane Devick-Fry and Teresa LeSage (2010) believe that the incorporation of literacy into the science classroom should be done through use of science literacy circles. Science literacy circles combine the use of science notebooks and literature circles as a way to promote literacy in the science classroom. Specifically, the authors describe science literacy circles as student-directed groups in which each group member agrees to read the same material. These science literacy circles contain three major components, which are science notebook organization, science literacy circle roles, and student-generated artifacts and big idea data charts. All three of these components happen simultaneously in an effective science literacy circle. The authors state that science notebooks are a great tool because they represent a collection of students' work. This collection of work includes reflection journals, lab write-ups, writing in multiple genres, class notes, and other important learning artifacts. Science literacy roles include the organizer, the word wizard, the visionary, the connector, the webmaster, and the big idea developer. The authors state that each of these roles in science literacy circle is vital, as it provides a dimension through which to think about the text. The authors state that the role of the organizer is to provide prompts that spark thinking about the text. These prompts should include questions about the title, main objective, hypothesis, procedure, materials needed, observations,

conclusions, and new ideas or questions. The authors state the role of the word wizard is to locate and circle familiar and unfamiliar vocabulary words. This role emphasizes the importance of vocabulary and how the meaning of words relates to understanding of the text. The authors state the role of the visionary is to create illustrations that relate to the text. These illustrations could include charts, diagrams, graphs, and more. The authors state that the role of the connector is to create a correlation between the content and everyday life. This role is extremely important because it helps students relate to the material on a personal level. The authors state that the role of the webmaster is to search the web and find additional information that is needed to understand the text. This role is important because it requires students to utilize other resources in order to help them maximize understanding. Finally, the authors describe the role of the big idea developer as one who completes the science literacy circle big idea chart. Through this process students are able to create meaning about a specific piece of literature by providing information that relates to their designated roles. Group discussion about the information provided from each member allows for the circular movements of ideas from each group member and paves the way for a big picture idea to develop. This big picture should relate directly to the text that a group chose to read and provide the main idea about the science concept or topic that the text focused on. During these science literacy circles, teachers should take on the role of a facilitator. The authors state that teachers should guide students in the right direction introducing them to a new concept, presenting prior knowledge, addressing unfamiliar vocabulary words, and circulating the room to ensure each science literacy circle is making progress. The authors implemented their idea of science literacy circles during an after school program help at a school in Texas. The topic for the science literacy circle involved the conduction of matter. Students were provided with many big idea charts that helped guide the

members in the direction of forming and investigation and creating conclusions from it. The big idea charts contained probing categories like purpose, motivation, and activation of prior knowledge. Each of these categories sought to help students determine focus questions, form hypothesis, and conduct investigations. From the individual roles of each student a big idea was developed and the authors found that the use of science literacy circles were very effective for these students. All five articles present valid ideas and possess many similarities and differences.

The five articles discussed above all represent the importance of incorporating literature into the science classroom. Although each article incorporates reading in a different way, all focus on the combination of reading with discussion. Straits et al. (2011), who wrote the article titled *Connecting Students to Science Through Structured Reading of Historical Nonfiction*, focused on the reading of historical non-fiction in combination with literature circles. Hoskins (2010), who wrote the article titled *But if It's in the Newspaper, Doesn't That Mean It's True?" Developing Critical Reading & Analysis Skills by Evaluating Newspaper Sciences with CREATE*, focused on the reading of newspapers in combination with a discussion and analysis method known as CREATE. Heisey and Kucan (2010), who wrote the article titled *Introducing Science Concepts to Primary Students Through Read-Alouds: Interactions and Multiple Texts Make the Difference*, focused on teacher-led-read-alouds in combination with during-reading discussions. Radcliffe et al. (2008), who wrote the article *Improving Reading in a Middle School Science Classroom*, focused on group work using the strategy PLAN. Finally, Devick-Fry and LeSage (2010), who wrote the article *Science Literacy Circles: Big Ideas About Science*, focused on the use of group science literacy circles to develop big picture ideas. Thus, five different discussion methods are suggested. The re-occurring theme of discussion methods presented in the text only further emphasizes the importance of discussion that accompanies reading.

Although each article is similar in this manner, one of the articles is significantly different from the other four. Heisey and Kucan present an approach in which incorporation of literature occurs through teacher-led-read-alouds. This approach is different from the other four because it involves the teacher reading to the students' instead of the students' reading by themselves. Heisey and Kucan believe this approach is better because it allows teachers to introduce students' to reading material that is above their reading level. Teacher-led-read-alouds is a great approach because it is often associated with being more enjoyable for students'. Although scientific material is very precedent and significant in historical non-fiction and newspapers, these texts may often be difficult for students' to read. They may be complex and written in a format that is challenging. Large vocabulary may also be a problem. However, due to the fact that both Straits et al., Hoskins, Radcliffe et al., and Devick-Fry and LeSage combine reading of these texts with some form of discussion group, students' will have the support they need to conquer these difficult readings. Science is a growing field. Everyday new information can be found relating to discovery, technology, experiments, and more. Due to this, it is important that we expose students' to scientific literature, especially those interested in pursuing scientific fields. These pieces of literature truly connect students' to the most important applications of science and real world examples. Each author seemed to agree with this idea and as one can see there are many feasible strategies that incorporate important literature into the science classroom. The next part of STEM literacy that is of high importance is mathematics. The following articles describe effective methods of incorporating literacy into everyday mathematics classrooms.

Mathematics

Along with science, mathematics is another part of STEM literacy that should be given high priority. There are many strategies that can be used to incorporate reading into the math

classroom. According to the article *Picture Book Power: Connecting Children's Literature and Mathematics,* Joyce Shatzer (2008) believes that children's literature is an excellent way to promote mathematical learning. Shatzer goes on to state that literature motivates students to learn and provides a way to create meaningful and personalized mathematical context to students. The use of literature to teach math also emphasizes how mathematics develops out of human experience. Shatzer pays special focus on the idea of human experience. She discusses ways in which she incorporates human experience into her teaching. One particular example she provided was when she read her students a book called "The Wolf's Chicken Stew," by Keiko Kasza on the Hundredth Day of School Celebration. The book discussed many different kinds of food. She asked each student what their favorite food was from the story, and had her class make a graph to determine which food was the winner for the class. Once the winner was determined, which in this case were chocolate chip cookies, her students' spent the rest of class looking at a chocolate chip cookie recipe. The class carefully measured the ingredients and made a hundred chocolate chip cookies. Shatzer states that children's literature can be the vehicle for meaningful learning in mathematics. One way to promote reading in the math classroom is to have a library. This library should contain books that are directly related to mathematics and indirectly related to mathematics, just as Shatzer's library did. She had books that focused on counting, fractions, money, and so on. Shatzer's library also contains children's books that are not just focused on math, but as she states, one can make math connections with almost any piece of children's literature. Children's literature, especially picture books, allows the teacher and students to enjoy stories and illustrations while making connections to mathematics simultaneously. Michael L. Tanner and Leah Casados also discuss how to incorporate reading into the mathematics classroom.

According to the article *Promoting and Studying Discussions in Math Classes,* Michael L. Tanner and Leah Casados (1998) proved that incorporating reading into the math classroom showed positive results. Leah Casados is a High School math teacher who was looking for ways to increase classroom discussion and change negative attitudes toward reading the mathematics textbook. She began to do this by implementing Socratic Seminars into her lesson plans. Socratic Seminars involve students discovering answers through exploration. Instead of students coming to the correct answer through the teacher's interpretation of the text, it assumes that knowledge and understanding are constructed by learners themselves rather than received (Tanner et al., 1998, p. 343). In other words, Socratic Seminars state that knowledge should not be the product of a teacher's efforts (Tanner et al., 1998, p. 343). Casados implemented this strategy for all seven chapters that she was required to teach for the school year. She used Socratic Seminar Discussions as a post reading activity for her students. After assigning reading from the mathematics textbook for students to do on their own time, discussions took place the following class period. Students sat in a circle, with each student being required to participate. To prepare, Casados had to be very familiar with the math reading so that she could point out important points. When deciding what particularly she was going to assign for students to read, she looked for the author's use of color, italics, spacing, vocabulary, questions, examples, and sequence of ideas. Her main discussion objectives involved analyzing and reconstructing the authors meaning and helping students formulate their own meaning (Tanner et al., 1998, p. 343). This discussion lasted for approximately thirty minutes. She provided surveys during a debriefing period held after the discussion to detect student attitudes and opinions about the Socratic Seminar Discussion. As time went on, results showed that student attitudes became more positive and optimistic about the Socratic Seminar Discussions. Casados also noted changes in her students'

comprehension. She states that her students' became more insightful, logical, mathematical problem solvers. Further more, she noticed an increase in vocabulary when discussing mathematical concepts, an increase in articulation of concepts, and increased participation. She also noted that her students' attitudes toward reading mathematics improved greatly. Margaret E. Mclntosh and Roni Jo Draper also discuss how reading can be incorporated into the mathematics classroom.

According to the article *Applying the Question-Answer Relationship Strategy in Mathematics,* Margaret E. Mclntosh and Roni Jo Draper (1995) believe that incorporating reading into the mathematics classroom is vital to a successful mathematics education. Mclntosh and Draper state that mathematics textbooks are changing due to the National Council of Teachers of Mathematics. This council believes that learning to communicate mathematically involves the use of reading, writing, and discussion of ideas (Mclntosh et al., 1995, p.120). Mclntosh and Draper discuss a method that can be used to ensure the teaching of reading and mathematics simultaneously. This method is known as the Question-Answer Relationship strategy, or QAR. The QAR strategies that Mclntosh and Draper taught to their students are the "Right There QARs," the "Think and Search QARs," the "Author and Me QARs," and the "On My Own QARs." Each of these strategies represents the relationship between the question and answer. "Right There QARs" represent a relationship in which the answer is clearly stated in the textbook, usually in one specific sentence (Mclntosh et al., 1995, p. 121). "Think and Search QARs" represent a relationship in which the answer is stated in the textbook, but not in one sentence (Mclntosh, et al., 1995, p. 121). These questions involve thinking and searching through the text. "Author and Me QARs" represent a relationship in which the answers cannot be found in the text (Mclntosh et al., 1995, p. 121). However, one should be able to answer the question by

applying the information given in the text and using prior knowledge (Mclntosh et al., 1995, p. 121). “On My Own QARs” represent a relationship in which the answer cannot be found in the text or by applying the information from the text (Mclntosh et al., 1995, p. 123). It is completely based on prior knowledge and experience (Mclntosh et al., 1995, p. 123). Mclntosh and Draper provide specific methods of implementing these QARs into the classroom. For each QAR a detailed five-step process is used. First, the instructor must start with a grabber that captures the students’ attention. Once they have the students’ attention they can proceed with an introduction of the QAR, including a definition. Second, a specific example is given by using a piece from the mathematics textbook. This piece should pertain to the current material the students’ are learning. After the piece of text from the mathematics textbook is read, a question with answer and relationship should be explained. Third, guided practice should take place through use of the textbook. Students should be required to find the relationship between the questions and the answers. Fourth, continued guided practice should take place. In the fifth and final step, learning logs are filled out. When implementing “Right There QAR” into the classroom, Mclntosh and Draper gave specific details on how they did this. They began with a humorous “grabber” that instantly captured the students’ attention and connected their experience to the new concept that was going to be taught. Then, a series of questions were asked pertaining to the “grabber.” The students easily answer each question. Then, students were introduced to the QAR label and definition. Next, Mclntosh and Draper moved to the second stage, where they provided an example of the students’ text pertaining to the material that they were currently learning. From this, Mclntosh and Draper walked the students through an example of identifying the relationship. At this point, teaching of content information took place. After instruction of content material, students were moved to step three, where they worked on a worksheet that

provided them with guided practice using their textbook. Once this was completed, students moved to step four, where they had further opportunities to identify the relationship between the question and answer. Finally, learning logs were completed. These learning logs provided Mclntosh and Draper with knowledge about how much the students' had understood about QARs. When Mclntosh and Draper introduced "Think and Search QAR," they began with a "grabber" from the book titled "Math for Smarty Pants." This "grabber" was a logic problem. The authors then went on to solve the logic problem and demonstrate how the information needed to solve the problem was given in the text, but it required searching and thinking. The QAR label and definition were then given. The class was then moved to step two, in which they were given an example using a piece of the text that was relevant to what they were currently learning in class. The relationship was explained to them. Students then engaged in guided practice by filling out worksheets that incorporated the textbook. Completion of learning logs ended the class period. Next, Mclntosh and Draper implemented "Author and Me QAR." They did this through use of four word puzzles as the "grabber." The puzzle answers were designed so that only certain students could understand them. For example, this first puzzle involved knowing the school mascot. For new students, this was not an easy task. It was then pointed out that the author of the textbook, just like the author of this puzzle, assumed students' had prior knowledge about the subject that they could apply. Students were then taken through an example using a piece of text that pertained to the material currently being studied. Students then engaged in guided practice working individually and in pairs to fill out worksheets that incorporated the textbook and the QAR relationships learned thus far. Learning Logs were completed at the end of class. When Mclntosh and Draper implemented "On My Own QAR" into the classroom, they began by using a nursery rhyme as the "grabber." They then discussed the rhyme in great detail

by asking students open-ended questions. These questions sought to show the students that some questions involve only one's brain and personal ideas. They then pointed out that these types of questions could also be seen in mathematics. The students were then given the QAR label and definition, engaged in guided practice similar to the practice from other days, and completed learning logs. The importance of these QAR strategies to Mclntosh and Draper can be summed up in one sentence. The ability to answer questions and solve problems in mathematics requires varying levels of book/brain involvement (Mclntosh and Draper, 1995, p.128). These QARs allow students to assess the difficulty level of mathematical problems and help guide them in taking the right steps to solve it. In order to provide additional reinforcement and application of the QARs, Mclntosh and Draper suggested three activities to use. The first is called the "Identification Activity." In this activity students are put into groups of four and are asked to write down hints and suggestions used to help identify each type of QAR. Each group then presents their results to the class. The second activity is called the "Paper plate Activity." In this activity students are put into groups of four and are given four paper plates. Each paper plate is a different color and corresponds to a different QAR. The instructor will call out a problem number and each group must decide which QAR it represents. Once they come to a conclusion they hold up the appropriate paper plate. The third and final activity suggested is called the "Quadrant Activity." In this activity each student is given a sheet of paper that has been divided into quadrants. Students must pick a question from the textbook, write it down in the quadrant labeled "Question," and then write down which QAR they think it is in another quadrant. The students must then trade with someone and evaluate each other's, writing down their answer in another quadrant. When concluding the article, Mclntosh and Draper stressed the importance of QAR and stressed that it is more effectively taught over a long period of time and in small

chunks. David Pugalee also presents an effective strategy used to incorporate literacy into the mathematics classroom.

According to the article *Using Communication to Develop Students' Mathematical Literacy,* by David Pugalee (2001), communication is the key to promoting mathematical literacy. Providing students with the opportunity to communicate mathematically allows students' to develop and strengthen skills that are necessary for mathematical literacy or that make them mathematically literate. The National Council of Teachers of Mathematics has put a large emphasis on the importance of communication in the math classroom. They state that students who are given the opportunity to "speak, write, read and listen in math classes reap dual benefits: they communicate to learn mathematics and they learn to communicate mathematically." Pugalee discusses an activity that relies heavily on mathematical communication. Through this activity students develop and strengthen skills that make them mathematically literate individuals. Pugalee describes this activity by stating that students solved a story problem by communicating their logic in the form of a written response. Then, students use a rubric to rate the written response of a peer. Finally, students must discuss their rationale for the score they gave their peer. Specifically, the story problem that was used in Pugalee's example was: Find the dimensions of a pool having a perimeter of 18 and an area of 18 square meters. Having students discuss their logic and approach to solving this problem in the form of a written response proved to be very powerful. Each response showed how each individual student approached the story problem, the mathematical thinking they exhibited, and how they organized their thoughts to present a clear explanation and analysis. Pugalee provides several examples of the written responses students had for this problem. Some exhibited the same ideas, while others were very different. For instance, one student used a guess and check method, while another student solved

this used more geometrical methods. Pugalee goes on to state that having students grade one of their peer's responses was just as beneficial as having student communicate their own written response. When grading the response of one of their peer's, students had to look for clarity, logic, strengths, and weaknesses. Doing this also allowed students to learn and build on the thinking of others, and respectfully critique and question the thinking of others. National Council of Teachers of Mathematics states that the complexity and difficulty of communication activities should build with each grade level. By the time students are in middle school and high school grade levels they should be utilizing higher-level literacy skills such as comparing and contrasting, and analytical thinking. Pugalee and NTCM believe that communication activities are the heart of a well-balanced mathematics education program. The underlying reason for this belief is that communication experiences pave the way for mathematically literate students. Faifth M. Wallace, Karen K. Clark, and Mary L. Cherry also present ideas for incorporating literacy into the mathematics classroom.

According to the article *Reading in the Mathematics Classroom,* Faith M. Wallace, Karen K. Clark and Mary L. Cherry (2006) believe informational trade books, literature, and environmental print are the key to mathematics literacy. The authors believe that the key to obtaining mathematics literacy is for students to be able to answer a series of questions like: How come? What if? and So what?. By infusing naturally existing text into mathematical instructions, the authors state that student engagement and understanding will soar. The first types of text the authors discuss are trade books. These books provide accurate knowledge, detailed information, illustrate concepts, and provide comparisons and contrasts about a particular topic. Many of theses books may also relate directly to students and their past experiences. In this article the authors discuss a selection of trade books and state how they promote mathematics literacy. The

first trade book discussed was *Fantastic Feats and Failures.* This book highlights both the accomplishments and failures of engineering projects. For example, the book specifically talks about the Eiffel Tower and the Brooklyn Bridge as being some of the greatest feats in modern engineering. The Leaning Tower of Pisa was recognized as one of the greatest failures in modern engineering. All of these monuments may directly relate to students in many ways. Some may have visited these places; others may have seen them on television, in movies, or in pictures. Others may fantasize about visiting these monuments or the cities in which they reside. Some students may even aspire to build a famous monument like one of these in their future. In terms of mathematics, this book provides students with a unique way to study figures and geometric measurements. Another trade book titled *Math Stuff,* was discussed. This trade book focuses on the wonder and power of mathematics in everyday life. Many creative and exciting topics were discussed, bringing mathematical concepts into topics that seemed to have no mathematical significance at all. One of these topics was a cricket chirp. The trade book explained how the number of cricket chirps heard is dependent on the outside temperature. During cold weather, a cricket chirp cannot be heard. However, as the temperature rises, the cricket chirps become louder and faster. Some other topics that are included in the trade book are the millennium clock, fractals, the fourth dimension, and nano-technology. Two other trade books mentioned were *Why Do Buses Come Threes?* and *Nature's Numbers.* The former focuses on topics such as sports rankings, coincidences, and bad luck, while the later focuses on the history of numbers. The second type of text the authors discuss is literature. Specifically, the authors state the literature should contain mathematics themes and concepts. One of the most beneficial aspects of literature, as the authors state, is that it provides a living through experience instead of just straight knowledge or facts about a topic. The authors discuss an abundance of literature that

contains many relevant mathematics themes and concepts. The first piece the authors discuss is a book called *Jayden's Rescue.* This book is an adventure of saving a princess who is being held captive in a labyrinth. At each doorway in the labyrinth a mathematical riddle is presented to the characters and must be solved in order to proceed. The riddles mainly focused on whole numbers, measurements, and the ability to problem solve. Another piece of literature the authors discuss is a book called *The Toothpaste Millionaire.* In this book, the characters decide to create their own toothpaste and sell it for a fraction of the price of the national brands. They also try to determine how much money they could earn if their profit from each tube of toothpaste was one cent. The authors really focused on this book because not only is it very entertaining and mathematically relevant, but it can also be replicated into a classroom environment. The authors' talk about a classroom activity in which a teacher had her students choose an item to make and sell. Students had to then calculate the cost of materials, packaging, labor and come up with a sale price. The next piece of literature the authors discuss is a science fiction book called *The Cold Equations.* This book is about a woman traveling in a spaceship to deliver medicine to ill men. The pilot believes that the woman is too heavy for the spaceship to reach its destination in space. The book incorporates the principles and laws from physics and mathematics in order to determine the conclusion. These are just some of the many pieces of literature that the authors discuss in the article. They provide students with very powerful, real-life examples of how mathematics can be relevant. However, students must have some knowledge and experience with certain mathematical concepts in order for them to fully understand and appreciate the plot and content in the story. The last type of text the authors discuss is Environmental Print. The use of environmental print in the classroom has many benefits. Along with the fact that there is a large abundance of environmental print, it also links mathematics to students' everyday life by

providing them with ways to apply mathematics in a consumer society. Some examples of environmental print that the authors' discuss include sale flyers, coupons, advertisement, newspapers, and lottery tickets. When studying sale flyers, coupons, and advertisement students can learn the importance of percents, ratios, and the importance of reading the fine print. Specifically, they can undertake percent problem-solving situations like deciding if an additional twenty percent off an already ten percent-discounted price is the same as thirty percent off. The importance of reading fine print is also examined because students will learn that there are restrictions and limitations that the sale may be related to and could potentially have a large effect on their overall purchasing decision. The authors state that the sports section in newspapers is particularly beneficial when studying statistics. Finally, the authors discuss that the use of lottery tickets are an excellent tool that can help students learn probability. Specifically, the odds of actually winning and the idea of buying more tickets to ensure a win can be taught through a classroom lottery sale manipulation. The authors believe that the use of these three kinds of text in the classroom will provide beneficial experiences for students and help connect mathematical concepts to students' lives. The use of informational trade books, literature, and environmental print in the classroom provide students will the opportunity to think critically and problem-solve, which both promote mathematical literacy. All five articles presented above possess both similarities and differences in their approach taken to incorporate reading into the mathematics classroom.

The five articles discussed above all present the importance of incorporating reading into the mathematics classroom. Each article showed unique approaches to how reading can benefit a students' mathematical progress. The articles strongly emphasized the importance of literature in mathematics by seeking to make changes that support the National Council of Teachers of

Mathematics. NCTM has made reference to the importance of literature in the classroom. However, each of the five articles takes a different approach as to how the incorporation of reading into the mathematics classroom should be done. The article written by Shatzer (2008), titled *Picture Book Power: Connecting Children's Literature and Mathematics*, discusses the use of outside literature being incorporated into the mathematics curriculum. By outside literature, one is merely referring to literature other than the mathematics textbook used for the class. Shatzer's approach seems to take on a more light-hearted view. She discusses the incorporation of children's literature and often refers to how she thought "out of the box" for ways to tie it to classroom content. She states that mathematical connections can be made with almost any piece of children's literature. Thus, she chooses fun and entertaining material as a way to excite her students and create innovative lesson plans. The article written by Wallace et al. (2006), titled *Reading in the Mathematics Classroom,* also discusses the use of outside literature. Specifically, the authors refer to trade books, literature, and environmental text as a way to get students to connect to mathematical content in a unique way. Unlike Shatzer and Wallace et al., the other articles focus solely on usage of the mathematics textbook as a way to promote literature in the classroom. All three articles discuss specific approaches taken to do this. The article written by Tanner and Casados (1998), titled *Promoting and Studying Discussions in Math Classes*, focuses on changing negative opinions about the mathematics textbook. They seek to accomplish this through use of Socratic Seminars, which are class discussions that take place after reading from the mathematics textbook has occurred. They did take color, italics, vocabulary, and other literary components into consideration when choosing the specific text for their students to read. They also stated that this method proved to create more positive attitudes towards mathematics textbook reading. However, their method seems to lack creativity. Although the discussion

section required entire classroom participation, its focus was solely on the mathematics textbook information, which is often dry and lacks personal meaning to students'. Unlike Shatzer and Wallace et al., their approach did not truly connect students' to content material. On the other hand, their thorough post reading discussions were beneficial for all students, especially those who struggled with the readability level of the textbook. The article written by Mclntosh and Draper (1995), titled *Applying the Question-Answer Relationship Strategy in Mathematics*, also focused on specific usage of the mathematics textbook. However, Mclntosh and Draper take a much different approach then Tanner and Casados. Their approach called Question-Answer Relationship, also known, as QAR was very beneficial to students. This strategy was particularly beneficial to students' because it taught them how to read a mathematics textbook, which is a different type of reading. The strategy focused specifically on helping students to understand how to read a mathematics textbook by showing them what to look for, and how to use the text to answer questions. Teaching students how to identify different questions and then how the text provided relates to that question is something that students' can utilize over and over again. This approach is unlike Tanner and Casados's approach because it specifically shows students' how their mathematics textbook is important and how to use it. Mclntosh and Draper utilize many creative and innovative methods when implementing this QAR strategy into their classrooms. This is also unlike Tanner and Casados, whose method requires students' to be focused and serious at all times. The article written by David Pugalee (2001), titled *Using Communication to Develop Students' Mathematical Literacy,* also utilizes the textbook, but in a very different way than Mclntosh and Draper and Tanner and Casados. Pugalee uses specific story problems from the textbook, but seeks to teach students mathematical literacy by focusing on communication. He does this by having students write written responses, describing the methods they used to

solve a story problem. Then, he has students exchange responses and analyze each other's writing and thought process. This is a very powerful method because it allows students to communicate their thoughts in writing and then analyze the mathematical thoughts of others. All articles brought up excellent points; however, one of the best points was brought up in Shatzer's article. In her article she discussed the importance of having a library in the mathematics classroom. This is an outstanding suggestion and something that is most definitely not common in classrooms today. Having a library that displays books related to mathematics both directly and indirectly seeks to make mathematics fun, depicts real world applications, and makes math personal and meaningful. After reading these articles, one can create many applications that incorporate reading and mathematics simultaneously.

Incorporation of literacy into science and mathematics classrooms is important. However, the way that it is incorporated is also important because certain strategies will have a larger impact on students than others. All ten articles presented above provided innovative and effective methods to follow when incorporating literacy into the science and mathematics classroom. Specifically, each method seeks to relate to the needs of the student, allowing them to make personal connections with the text. Making students scientifically and mathematically literate is a STEM endeavor and will lead to higher levels of understanding and increased interest in STEM related fields.

PART II:

This section of the research paper will focus on the incorporation of technology and engineering into the classroom. Research articles will be analyzed that show how quality educational experiences enhance STEM knowledge, interest, and literacy. Two professionals

were also interviewed, and their knowledge and ideas on STEM education, specifically in the areas of engineering and technology, will be presented.

Engineering and Technology:

The great educational philosopher John Dewey (1997) once stated in his book *John Dewey Experience & Education*, "the lesson for progressive education is that it requires in an urgent degree, a degree more pressing then was incumbent upon former innovators, a philosophy of education based upon a philosophy of experience" (p. 29). In the 21st century, this quote still holds great truth and honesty. A progressive education, in which there is a student-centered environment with constant connection being made between experiences and education, will pave the way for STEM literacy. In order for America to prepare for its future, quality STEM experiences need to occur in the classroom. Only with these quality STEM experiences, will students become scientifically and mathematically literate and gain the interest or desire to pursue STEM related careers. Creating lessons that provide students with quality STEM experiences is challenging, but there is an abundance of research that seeks to guide teachers in how to do this and many knowledgeable people who are willing to help. The key is to make teachers aware of the resources that are available to them and provide them with access to STEM lessons that are already being implemented.

According to the article *STEM Day in the Park*, by Kathleen Bledsoe (2012), quality experiences most definitely increase student interest and excitement towards STEM content. In Huber Heights (Ohio) city schools, over two hundred and fifty students and their family member gathered in a park field to experience the power of STEM education. Teachers of all grade-levels, higher-education teachers, industrial leaders and volunteers came together to provide elementary and middle school students with a STEM education day. The purpose of this day was not only

for students, but parents as well, to be able to witness the importance of STEM education. This project was funded through the Toyota Tapestry Grant and through donations. The most important aspect of this project was the innovative lessons that were provided for elementary and middle school students. There were three stations available for elementary students and three stations available for middle school students. Each station sought to engage students in problem-based learning, scientific inquiry, and engineering design process. The lesson at each station also incorporated specific content standards and promoted teamwork, communication skills, critical thinking and creativity. Problem-solving, scientific inquiry and critical thinking are all attributes that contribute to STEM literacy. The three stations available for elementary school students were the "Let It Shine" station, the "Wind Speed" station and the "Compressed Air" station. At the "Let It Shine" station students learned about the transmission of light. They tested familiar objects and recorded observations. These observations lead them to conclusions on how well certain objects transmit light. In their study, they also learned about translucent, transparent, and opaque objects. At the "Wind Speed" station, students designed, built, and flew kites at various wind speeds to study propulsion. At the "Compressed Air" station students studied the relationship between the amount of compressed air and the distance a vehicle travels by designing and building cars. The three stations available for middle school students were, the "Warm Home Solar Style" station, the "Electric Motor" station, and "It's Not Rocket Science" station. At the "Warm Home Solar Style" station students designed and built a model home and investigated how solar energy could be used to warm the home they built. They investigated through trial and error with different materials, different colors, and different lengths of exposure to the sunlight. The "Electric Motor" station focused on understanding how an electric motor works. Students studied a DC electric motor, identifying the major parts and then built their own

electric motor that was powered by one double A battery. The "It's Not Rocket Science" station focused on building rockets, launching them, and testing their design by observing what factors have an affect on the altitude a rocket reaches. All of these lessons were designed and developed by teachers, higher-education teachers, and industry leaders. The lesson from each station can be found at the Dayton Regional STEM center website and are available for teachers to utilize. This project proved to be very successful. The main reason for its success is that it created quality educational experiences for students. These lessons engaged students while simultaneously increasing their STEM literacy through use of critical thinking skills, problem-solving skills, and scientific inquiry. David Crismond, Mark Soobyiah, and Ryan Cain also provide insight into the importance of quality STEM experiences.

According to the article *Taking Engineering Design Out for a Spin*, by David Crismond, Mark Soobyiah, and Ryan Cain (2013) discuss how both scientific inquiry and engineering design, both STEM endeavors, can be combined into simple, yet innovative projects. Specifically, the authors focused on the importance of observation, developing a question, research, hypotheses, building prototypes, conducting experiments, interpreting data or troubleshooting, and communication. The authors created a lesson called the Whirligig Design Challenge that sought to implement all of these tasks. The Whirligig is a very simple design. It is made using a template pattern, paper, and paperclips. When dropped from a fair distance above the group, it spins and falls. During this Whirligig Challenge, students were asked to design a spinning toy for children that would fit inside a box of cereal. Authors Cain and Soobyiah both implemented this activity in their classroom, each with a different goal in mind. Cain wanted to introduce design and fair-test experiments to his class, while Soobyiah wanted his students to learn the importance of troubleshooting and the combining of ideas to create a master design product. Each, however,

followed the same sequence of steps with their class. First, they identified the problem, which focused on reading students' the instructions of the challenge, and the criteria and constraints of the Whirligig. Specifically, the Whirligig had to be a toy that took a long time to fall a certain distance, and it had to be something that would capture the interest of children. The Whirligig also had to be made of low-cost materials, and had to fit inside a box of cereal. Then, students were given time to research. During this research time, students used a template, scissors, and paperclips to make the Whirligig. The template that was given to students allowed them to form a Whirligig that worked, but had significant room for improvement. Then, students focused on building prototype. During this time students tested the Whirligig that they built and watched video-recordings that the teacher was taking. These video-recordings allowed students to focus on the details of their Whirligig, such as the speed of descent, the speed and direction of spinning, the straight or curved pathway the Whirligig took, and the stability of it. Next, students began to conduct their experiment. They did this by picking one specific feature about their Whirligig to focus on and make changes to. They then tested the changes they made by comparing the descent of their new Whirligig to their original one. The next step was troubleshooting. During this step students focused on observing and identifying issues with their design, why the problem was occurring, and strategies or ideas to improve it. Students recorded their troubleshooting in a notebook, which served as a formative assessment for teachers. The main purpose of this troubleshooting step was for students to eventually come up with a master design. All of the steps that each of these teachers included in this lesson focused on the ideas of problem solving and critical thinking, which are key components of developing STEM literate students. Students also had to take the science concepts they learned and apply it to their design. Both teachers stated that this lesson was very effective and engaged their students. They both stressed the

importance of design-based activities and stated that when implemented well, these types of activities can lead to enhanced scientific learning and a deeper understanding of science concepts. This project was just one example of a low-cost, hands-on activity that provided students with a quality STEM experience. Georgia A. Cobbs also provides a way to provide students with quality STEM experiences in the mathematics classroom.

According to the article *Getting Into Gear*, by Georgia A. Cobbs (2011), combining the study of ratios with motorized toys is an excellent way to provide students with a quality STEM experience. The Society of Automotive Engineers, SAE, is largely involved in a program called A World In Motion, also known as AWIM. General Motors is the largest contributor to AWIM and its success is a direct result of their donation and funding. AWIM is program run by SAE that seeks to bring science, technology, engineering, and mathematics to life inside the classroom. They provide challenge kits that contain projects for teachers to implement inside their classroom. Teachers can apply for these challenge kits and either get them for free or for very low cost. The project used in this article to teach students about ratios was a challenge kit provided by AWIM. In this project, students were presented with a request for proposal to design and prototype a new toy that appealed to kids from six to ten years old. Certain criteria were given to them. Specifically, the motorized car had to travel three meters under its own power in under three seconds and had to either climb a thirty-degree slope under its own power for one meter or a fifteen-degree slope for two meters. Students were also responsible for building the framework of the toy that housed the gear configuration and for making the gear configuration work. To learn about gears and how ratios are related, the teacher used bicycles as an example. During this example the teacher talked about the two different gears, the driver gear and the driven gear. Students learned that the rotation of the driver gear to the driven gear is three to one.

From this understanding of gears and ratios, students began to design their motorized toys from a kit that was provided by AWIM. When building their motorized toys, students kept design logs. In these design logs, students wrote a daily journal of their progress, took lecture notes, wrote new vocabulary words down, made sketches, and wrote commentary on their sketches. This provides the teacher with a way to evaluate student progress. This project addressed both math and science standards. It also promoted scientific inquiry, asking questions, planning, conducting investigations, gathering data, and thinking critically and logically about relationships. All of these are STEM endeavors and are contributors to increased literacy levels. Although the main goal of this project was simple, to teach students the basic concept of a ratio, the experience provided much more. Students were presented with a real-world application of math, how ratios play a role in real life, and were able to partake in an engaging, innovative, and quality STEM experience.

There is an abundance of research articles and resources that support STEM education. From the articles above, it becomes clear that STEM education involves providing students with quality experiences to teach them about science, technology, engineering, and mathematics. Although the three articles above presented different activities, they all provided students with an engaging and quality experience. The first article, *STEM Day in the Park*, by Kathleen Bledsoe (2012) presented six different activities that provided students with quality STEM experiences. Students participated in everything from learning about transmission of light, building and flying kites, building cars, launching rockets, designing houses that capture solar energy, and building an electric motor. Although these activities were done at a local park, the article states that they could also be implemented into a school setting as well. The second article, *Taking Engineering Design Out for a Spin*, by David Crismond, Mark Soobyiah, and Ryan Cain (2013) provided a

simple and low-cost activity that could be developed to provide students with a quality STEM experience. Students went through a series of steps that lead them to a master Whirligig design. Finally, the third article, *Getting Into Gear*, by Georgia A. Cobbs (2011) used the designing of motorized toys to teach her students the basic concept of a ratio. All of these projects promoted problem solving, critical thinking, scientific inquiry, and creativity, all of which are the basis for STEM literacy. Each article also emphasized the importance of how the STEM experience impacted their students. All of these experiences resulted in student engagement, and in the end, resulted in a deeper understanding of the basic concepts being taught. Another important point that should be noticed from these three articles is the resources that are available to teachers. From these three articles, three important resources can be noted. The first resource is the Dayton Regional STEM Center. This center has a website with an abundance of information available to teachers, including lesson ideas. The second resource is AWIM, sponsored by General Motors. AWIM also has a website with an abundance of information available. The third resource is research. There are many journals with quality STEM education ideas available. In order to present further research on STEM education and how technology and engineering can be implemented into math and science classrooms to provide students with quality experiences, two people were interviewed. The first professional who was interviewed was Scott Levitan, who is a middle school technology teacher at a local Detroit Metropolitan school. The second professional who was interviewed was James Mitts, who is a retired automotive engineer from General Motors. Both of these professionals provided quality information about STEM education, literacy, and experiences.

Interviews:

The following sets of questions were asked while interviewing middle school technology teacher, Scott Levitan, and automotive engineer, James Mitts.

Technology Interview Questions

1. How long have you been teaching Technology at this Middle School?
2. Why did you choose this area of teaching?
3. Please describe the main objective/purpose of the technology classes that you teach.
4. What types of technology is part of your class?
5. Please describe how math and science concepts are a major part of your class.
6. Please describe some of the projects that you do with your technology classes.
7. Please describe how your class promotes critical thinking skills and gets students interested in science and math.
8. Do you think your class promotes interest in science and math related careers?

Engineering Interview Questions

1. Please tell me about your credentials and your professional career?
2. What is your background knowledge with STEM education?
3. Why did General Motors start their initial investment in the program?
4. What are some of the ways that General Motors promoted/supported STEM education?
5. Please describe some of the STEM initiatives that you took part in while working for General Motors.

6. Why do you think General Motors took this initiative?

7. What outcomes were General Motors looking for when they took this initiative?

8. What do you feel are currently some of the major problems in math and science classrooms?

9. What do you feel are the best ways to incorporate engineering into the math/science classrooms?

10. How do you feel we can get students excited about math/science related careers and provide them with the foundation they need to pursue those careers in higher education?

In order to gain an understanding on how technology can be incorporated into the classroom and how quality STEM experiences can be created, a Technology teacher at a Detroit Metropolitan middle school was interviewed. This teacher, Scott Levitan, has a Master's Degree in the art of teaching and an undergraduate Education Degree in Design and Technology. It is because of this Design and Technology degree that this interviewee has been a technology teacher for over fifteen years. The middle school where Levitan works at has a large technology program. The program offers technology classes for sixth, seventh, and eighth grade students. For the current school year, however, only sixth and eighth grade technology classes are being run. Recently, the technology classroom was renovated and re-designed. This teacher was given a budget of ten thousand dollars to update the room and buy resources that would benefit the class. The classroom is broken up into two parts. The main part of the room is equipped with desks and computers. Attached to the classroom is an entire lab or shop, as Levitan calls it. This shop is equipped with workstations for students, hand tools, and a variety of power tools.

The technology program has two main objectives. The first objective is for students to be technologically literate. Specifically, being technologically literate refers to being able to use the computer, textbook, and shop equipment effectively and efficiently. The second objective is to promote engineering. According to Levitan, the technology and design programs within schools has been reformed. Technology classes used to be associated with metal-smithing, or woodshop classes. However, with the current and competitive 21st century global economy, Governor Engler reformed the program, calling it Design and Technology. This program was specifically created to promote engineering in our grade school students.

The technology classes that Levitan teaches are composed of three main subgroups. These subgroups are computers, industrial technology, and biotechnology. The computer subgroup focuses on design, blueprints, CAD programs, researching and writing. The industrial technology subgroup focuses on use of power tools. The shop, attached to the main classroom, has an abundance of power tools available for students to use. These power tools include the drill press, ban saw, disk sander, wood lathe, and scroll saws. The biotechnology subgroup focuses on industry, medicine, and agriculture. Being a project-based class, students conduct projects that introduce them to each subgroup and the concepts that make up each one. Specifically, students make catapults, mousetrap cars, carbon dioxide cars, water bottle rockets, prosthetic hands, and maglev vehicles, build bridges, and partake in recycling routines. These projects focus greatly on science and mathematical concepts and principles. The reason for this is that the technology class is most associated with these two subject areas. In technology, students study major science concepts like force, friction, tension, torsion, lift, drag, and much more. Major math concepts are also utilized like taking measurements, working with fractions, and other basic math skills. Students spend an abundance of time learning about these science and math concepts and then

applying and testing them in projects. Thus, this project-based class is providing students with quality STEM experiences.

This is a very hands-on class with many innovative projects. Thus, this class definitely makes students excited about careers that require science and math background. Specifically, it has promoted students to pursue higher-level technology courses offered at the high school level, like robotics. Aside from this, this class has also promoted women in the field. Levitan stated that in the beginning of his career, technology class was mainly associated as a class for the male gender. However, over the years he has witnessed a drastic change, and currently has classes with more female students than male students. He states that this makes him very happy, especially because there is a need for women in STEM related fields. He hopes that his class has helped bridge this gap in some small way.

In order to gain an understanding on how engineering can be incorporated into the classroom and how to create quality STEM experiences, an automotive engineer from General Motors was interviewed. James Mitts, has a master's degree in mechanical engineering from Lawrence Technical College. With over twenty-eighth years of experience in the field of engineering, Mitts has an abundance of knowledge with not only engineering, but STEM education as well. Through involvement with Society of Automotive Engineers (SAE) and A World In Motion (AWIM), Mitts has gained experience with going into classrooms throughout metropolitan Detroit and leading students in engineering related activities. AWIM has over 65,000 challenge kits to provide teachers with and each kit is benchmarked to the national standards. Mitts involvement with AWIM has been very positive and is one of the main reasons that he is pursing a Masters of Education in his retirement.

During Mitts involvement with AWIM and another organization called Young Engineers and Scientists (YES) he has had the opportunity to go into classrooms and aid teachers in engineering related projects. Specifically, he has lead students in experiments that involve the design of a paper boat, and the creation of a clay model of the car. During both of these experiences he has lead students by introducing them to engineering, teaching them how to effectively research, helping them with their designing skills, making sketches, experimenting, troubleshooting, and providing the materials. He has also gone into classrooms to promote students interest in the field of engineering. During this game students would get to ask questions, explore their future career possibilities, and discover their interests by learning about how relevant engineering is in our society.

In order to get students interested in STEM careers and provide them with the foundation they need to pursue those careers in higher education, Mitts believes the answer is to provide students with real-life experiences. He believes that students need to be able to relate the concepts they are learning. However, he also stressed the importance of the student-teacher relationship. STEM activities, although fun and engaging, can often be very challenging and require a great deal of perseverance from students. Having a positive relationship established between the teacher and the student is key in order to get students to take risks and allow their teacher to push them. If students have trust and confidence in their teacher, and look forward to coming to class, they will be willing to put their best effort forth and will embrace the challenges their teacher presents them with.

General Motors has taken a large initiative in promoting STEM education. They have chosen to support the STEM initiative by donating engineer's time and involvement in STEM education, and providing grants to schools for STEM related activities. Mitts believes he main reason that

General Motors has supported this STEM initiative is to promote their own future. The company wants to increase the level of awareness to students about careers in engineering. In order to do this, students need to be presented with quality STEM experiences that get them excited about what they could do with their future.

Both of these interviews provided very valuable information. Each focused on the importance of combining technology and engineering with mathematical and scientific concepts to promote STEM literacy. Through the quality STEM related experiences that both interviewees discussed, students used problem-solving skills, critical thinking skills, and creativity. All of these skills lead to higher levels of STEM literacy. Scott Levitan has showed us how a technology class can incorporate science, technology, engineering, and mathematical concepts simultaneously. Through projects, students learned how to work with a variety of technology, apply math and science concepts to a master design, and use critical thinking and problem solving skills. Students in this class also have to write research papers and reports. James Mitts has showed us how engineering can play a large role in the classroom. Through his experience, Mitt has shown how engineers have sought to promote students interest in STEM related fields. Specifically, Mitt talked about resources that are available to teachers, like AWIM, and discussed some of the quality STEM experiences that he has lead students through. Like the projects in Levitan's technology classes, the projects that Mitts lead students through also promoted problem solving, critical thinking, and creativity. Thus, a general trend can be identified. The main way to promote students interest in STEM related fields and to promote STEM literacy is to provide them with quality STEM experiences. These quality STEM experiences are not only engaging and innovative, but they require students to think critically and apply their knowledge to real-life situations. In this 21st century global economy, this is what America needs.

CONCLUSION:

In this 21st century global economy, STEM literacy is a high priority. Educators around America need to be preparing students for careers in STEM. Through research, there have been many strategies identified that incorporate literacy into the science and mathematics classrooms. All of these strategies have one important factor in common. They all seek to reach out the student and provide them with a way to connect to the text. Research has also shown that providing students with quality STEM experiences not only sparks interest in STEM related fields, but also promotes STEM literacy. All teachers should explore the methods suggested in this research paper, along with other creative applications they can generate. In order to prepare students' for the global economy of the twenty first century, educators must make STEM literacy a priority in their classrooms.

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